FTD-ID(RS)T-0395-86

AD-A167 951

FOREIGN TECHNOLOGY DIVISION

REMARKS ABOUT THE LIFETIME OF A FIREBALL

by

Ye. L. Feynberg

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86 5 16 113

FTD-ID(RS)T-0395-86

HUMAN TRANSLATION

FTD-ID(RS)T-0395-86 1 May 1986

MICROFICHE NR: FTD-86-C-001788

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English pages: 5

Source: Nukleonika, Vol. 13, Nr. 1, 1968, pp. 1-4

Country of origin: USSR
Translated by: Carol S. Nack
Requester: FTD/TQTR
Approved for public release; Distribution unlimited.

Accession For	
NTIS GRA&I	X
DTIC TAB	
Unannounced	
Justification	
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Availability Codes	
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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

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REMARKS ABOUT THE LIFETIME OF A FIREBALL

Feynberg, Yevgeniy L.
Physics Institute of the Academy of Sciences, Moscow

The possibility of the experimental determination of the lifetime of a fireball is discussed in this report.

nuclear

The idea of the generation of pions by the formation of an intermediate system - a "radiating center" - with a baryon number of zero (and, obviously, decaying isotropically in its rest frame) which was proposed by M. Mensovich and associates and which has been substantially confirmed in the remarkable works of this group, as well as in the works of other researchers - the idea of fireballs - continues to be the subject of many investigations. One important problem remains that of determining the lifetime of such a system.

We will point out that as the recent studies by D. S. Chernavskiy and coworkers [1] showed, the model of a fireball is by no means simply a rough empirical representation. Strictly studying the integral equation of the relativistic field theory, these scientists demonstrated that if certain entirely possible and plausible assumptions are made about the parameters in the equation (the behavior of the kernel of the equation), its solution has all the necessary analytical properties, it generates an asymptotically constant total cross section of the collisions, and it fully automatically leads to

the generation of pions by means of fireballs. The mass obtained for these fireballs is of the same order of magnitude as that indicated by the experiments of the Krakovskiy group and other laboratories, while the number of them in an individual event increases logarithmically with energy and does not contradict that observed in the laboratory of the Physics Institute im. P. N. Lebedev (N. A. Dobrotin and S. A. Slavatinskiy and coworkers) and at the Krakow Institute of Nuclear Research.

However, the dynamics of the decay of the fireball remains beyond the range of possibilities of this investigation.

Here we would like to discuss the problem of the possibility of determining the lifetime of the fireball.

First, we will note that as a rule, pion resonances have a width which is much smaller than that of baryon resonances. Sometimes they are much smaller than the mass of the pion μ. Furthermore, the diversity of resonances observed is very great, and it is entirely possible that the following statement is correct: any strongly interacting mesons taken in any combinations and in any number, are capable of forming short-lived resonances, i.e., relatively stable systems of meson matter with a baryon number of zero.

Moreover, resonances from four particles, e.g., from four pions, with a total electrical charge which does not exceed one have been obtained on accelerators. Therefore, it is not surprising that a large number of pions can generate a fireball. As the above reports by D. S. Chernavskiy et al. indicated, the fireball which originates in their theory cannot be considered to be like a resonance, since it does not have a specific value of the angular moment. However, in any case, we have a meson-nucleon plasma bunch which exists for a certain period of time.

We would like to bring attention to one theoretical possibility of the experimental manifestation of the prolonged existence of such a bunch. This manifestation can be the electromagnetic radiation of

the bunch besides that which occurs from the decay of π^0 mesons. This radiation can have two sources. The first - a trivial source - is the radiation that accompanies the escape of charged pions; it makes a weak contribution. The second - the thermal radiation of the heated body, which is the bunch - was considered in reference to hydrodynamic escape in the Landau theory in his time [2, 3], but it is of wider importance and can also prove to be considerable in the case of a fireball.

For the first source, the radiation of an escaping pion with energy E is the bremsstrahlung of the half-line beginning in the fireball and directed within the angle $\theta \lesssim \mu/E$ (at $E \sim 0.5$ GeV, $\theta \sim 1/3$). Its intensity (number of quanta) for the frequencies $\omega < \omega_{max} \sim \mu$ cut off by the pion form factor is

$$N_j \sim n_s \int_{\omega_{min}}^{\omega_{max}} \frac{2e^2}{\pi} \frac{d\omega}{\omega} \ln \frac{E}{\mu} \tag{1}$$

Here n_s is the number of charged mesons, and ω_{min} is determined by the requirement of the absence of interference between the emissions of different pions. When $E \sim 3\mu$, ω_{min} can only be several times smaller than μ. Thus, $N_j \sim 10^{-2} \cdot n_s$ on the fireball and, therefore, this effect is insignificant.

The thermal radiation is determined by the temperature fluctuations of the charge and current within a bunch with temperature T. As long as the bunch is expanding, this temperature can be higher than the critical escape temperature $T_k \sim \mu$. But during the generation of pions according to Heisenberg, the temperature $T \sim \mu$ is established immediately [4]. Therefore, we will consider the temperature T to be constant.

As was demonstrated earlier [2], the number of quanta emitted in this case with frequency ω, dN_ω for volume V during time τ in the direction of the unit vector $\vec{n}$ in the solid angle $d\Omega$ is given by the Fourier component of the current correlation function $\vec{j}$;

$$dN_\omega = \frac{1}{16\pi^3} V\tau d\Omega \omega d\omega \int e^{ik\zeta} (\vec{j}(\xi), \vec{j}(\xi+\zeta))\, d\zeta \tag{2}$$

where $q = (\omega, \vec{k}\omega)$ (see equations (6.5), (6.13) in [2]). Because of dimensional considerations, it follows that the correlation function, which is finitely proportional to the square of the charge e^2, must be proportional to l^{-6}, where l is a certain characteristic length of the correlation. Accordingly, the correlation function has the arguments $R/l\alpha$ and $t/l\beta$, where R and t are the space and time distance between the points at which the currents are selected, and α and β are dimensionless constants on the order of one. In the case in question, only the lengths 1/T and 1/μ are dimensional, and since $T \sim \mu$, we can consider:

$$(\vec{j}(\xi)\vec{j}(\xi+\zeta)e^2T^4G\left(\frac{tT}{\alpha}, \frac{RT}{\beta}\right), \tag{3}$$

where G is a dimensionless function.

$$G(0,0) = G_0 \sim 1.$$

For simplicity's sake, assuming that G has Gaussian form (a nontheoretical assumption), we obtain:

$$G = G_0 \exp\left(-\frac{T^2t^2}{\alpha^2} - \frac{R^2T^2}{\beta^2}\right),$$

$$dN_\omega = \frac{\alpha\beta^3}{4} V\tau e^2 T^2 G_0 e^{-\frac{\omega^2}{4T^2}(\alpha^2+\beta^2)} \omega d\omega.$$

We will introduce the dimensionless values for the volume and time of expansion:

$$V_0 = \frac{V}{\frac{4}{3}\pi\frac{1}{\mu^3}}, \quad \tau_0 = \frac{\tau}{\frac{1}{\mu}}. \tag{4}$$

Obviously, $V_0 \sim n \sim \frac{3}{2}n_s \sim$ 10-20; $\tau_0 > 1$. Then the total number of quanta N obtained by integration with respect to ω from 0 to ∞ is equal to (at $\alpha^2 = \beta^2$):

$$N = e^2 Q V_0 \tau_0 \left(\frac{T}{\mu}\right)^4, \tag{5}$$

$$Q = \frac{\pi}{3}\alpha^2 G_0$$

Thus, unless G_0 and α turn out to be anomalously small, when the

fireball lasts for a long time, the number of quanta can be greater than one, and it can become appreciable and measurable. Unfortunately, the energy of these quanta is of the same order of magnitude as those generated during the decay of neutral pions, and it may be difficult to distinguish them.

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